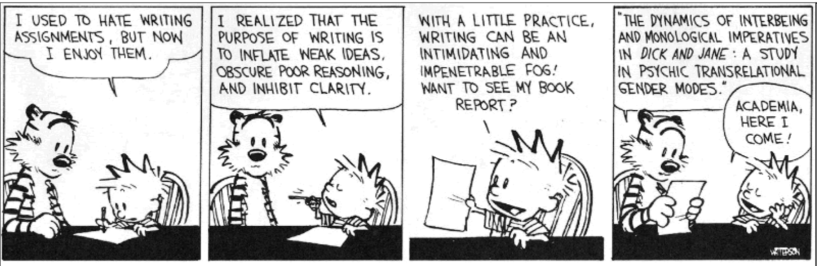

I USED TO HATE WRITING ASSIGNMENTS, BUT NOW I ENJOY THEM.
I REALIZED THAT THE PURPOSE OF WRITING IS TO INFLATE WEAK IDEAS, OBSCURE POOR REASONING, AND INHIBIT CLARITY.
WITH A LITTLE PRACTICE, WRITING CAN BE AN INTIMIDATING AND IMPENETRABLE FOG! WANT TO SEE MY BOOK REPORT?
"THE DYNAMICS OF INTERBEING AND MONOLOGICAL IMPERATIVES IN DICK AND JANE: A STUDY IN PSYCHIC TRANSRELATIONAL GENDER MODES."
ACADEMIA, HERE I COME!

Languages

An-cay uo-yay eak-spay ig-pay atin-lay?
Es-yay 43%
What? 57%
GraphJam

Labs Explained

- Wed Noon-1pm, Rice 423 Weimer Office Hours
  - Any questions on the course material or problem sets, but also grade change requests, etc.
- Wed 1pm-4pm, OLS 001 – Main Lab Hours
- Sun 1pm-6pm, OLS 001 – Main Lab Hours
  - You "must" be able to attend one of these two
- Others
  - In Thornton Stacks or OLS 001 or similar: based on your availability ...

Optional Textbooks

- "The Course Book"
  - Uses "Scheme" as early language of instruction; we use "Python"
- Udacity
  - Uses "Python", you watch videos and complete quizzes
- GEB – EGB
  - Does not describe any particular programming language. It's more of a novel.

One Key To Happiness: Setting Expectations

- I want to be more competent at computers, and I also hope to gain some skills that I can use in a competitive job market.
- if i put in the work will you honestly help me in this class and not blow me off because i dont understand something.
- I expect to learn the basics of computer science and whether or not I really want to major in it.
- I will never know the answer to a trivia question.

Outline

- Languages and Formal Systems
- BNF Grammars
- Describing Languages
- Learning New Languages
- Evaluation Rules

CATENA by Tracy Pierce
Tracy Pierce 01-23-2006
I WILL RULE THE WORLD! MARK MY WORDS...
I WILL RULE THE WORLD! MARK MY WORDS...
!
... I WOULD RUN.

What is a language?

Webster:

A systematic means of communicating ideas or feelings by the use of conventionalized signs, sounds, gestures, or marks having understood meanings.

What is a language?

Webster:

A ~~systematic~~ means of communicating ~~ideas or~~ ~~feelings~~ by the use of ~~conventionalized~~ signs, sounds, gestures, or marks having ~~understood~~ meanings.

Linguist's Definition

(Charles Yang)

A **language** is:

A description of pairs (*S*, *M*), where *S* stands for sound, or any kind of surface forms, and *M* stands for meaning.

A theory of language must specify the properties of *S* and *M*, and how they are related.

Languages and Formal Systems

What is the difference between a formal system and a language?

With a language, the surface forms have **meaning**.

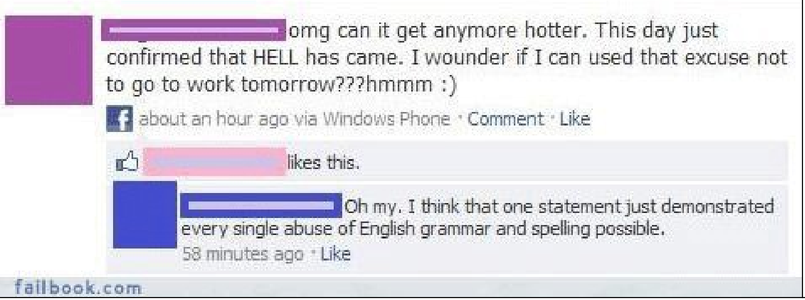
Caveat: computer scientists often use *language* to mean just a set of surface forms.

What are languages made of?

- Primitives (almost all languages have these)
  - The simplest surface forms with **meaning**
- Means of Combination (**all** languages have these)
  - Like Rules of Production for Formal Systems
  - Ways to make new surface forms from ones you already have
- Means of Abstraction (all **powerful** languages have these)
  - Ways to use simple surface forms to represent complicated ones

Does English have these?

- Primitives
  - Words (?)
- Means of combination
  - ?



[redacted] omg can it get anymore hotter. This day just confirmed that HELL has came. I wounder if I can used that excuse not to go to work tomorrow???hmmm :)

about an hour ago via Windows Phone · Comment · Like

[redacted] likes this.

[redacted] Oh my. I think that one statement just demonstrated every single abuse of English grammar and spelling possible.

58 minutes ago · Like

failbook.com

Does English have these?

- Primitives
  - ~~Words (?)~~
    - e.g., "antifloccipoccinihilipilification" – **not** a primitive
  - Morphemes – smallest units of meaning
    - e.g., **anti-** ("opposite")
- Means of combination
  - e.g., *Sentence* ::= *Subject Verb Object*
  - Precise rules, but not the ones you learned in grammar school

Does English have these?

- Means of abstraction
  - Pronouns: she, he, it, they, which, etc.
  - Confusing since they don't always mean the same thing, it depends on where they are used.

The "**these**" in the slide title is an abstraction for the three elements of language introduced 2 slides ago.

The "**they**" in the confusing sentence is an abstraction for pronouns.

How should we describe (Formal) Languages?

Backus Naur Form

symbol ::= replacement

We can replace *symbol* with *replacement*

A ::= *B* means anywhere you have an *A*, you can replace it with a *B*.

nonterminal - symbol that appears on left side of rule

terminals - symbol that **never** appears on the left side of a rule

BNF Example

Sentence ::= *NP Verb*
NP ::= *Noun*
Noun ::= **Wes**
Noun ::= **Python**
Verb ::= **rocks**
Verb ::= **sucks**

What are the *terminals*?

How many different things can we express with this language?

BNF Example

Sentence ::= *NP Verb*
NP ::= *Noun*
Noun ::= **Wes**
Noun ::= **Python**
Verb ::= **rocks**
Verb ::= **sucks**

What are the *terminals*?

Wes, Python, rocks, sucks

How many different things can we express with this language?

4, but only 2 are true.

BNF Example

Sentence ::= *NP Verb*
NP ::= *Noun*
NP ::= *Noun* **and** *NP*
Noun ::= **Wes**
Noun ::= **Python**
Verb ::= **rocks**
Verb ::= **sucks**

How many different things can we express with this language?

BNF Example

Sentence ::= *NP Verb*
NP ::= *Noun*
NP ::= *Noun* **and** *NP*
Noun ::= **Wes**
Noun ::= **Python**
Verb ::= **rocks**
Verb ::= **sucks**

How many different things can we express with this language?

Infinitely many!
Recursion is powerful.

Liberal Arts Trivia: Art History

- Q. Name the type of painting in which pigment is mixed with water on a thin layer of mortar or plaster. Because of the chemical makeup of the plaster, a binder is not required, as the pigment mixed solely with the water will sink into the intonaco, which itself becomes the medium holding the pigment. The technique was popular during the European Renaissance.

Liberal Arts Trivia: Music

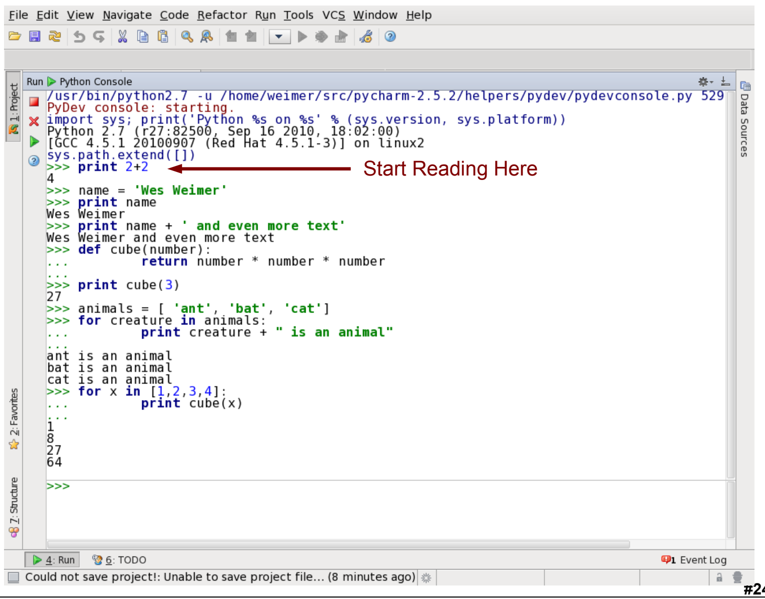
- Q. This Hong Kong singer is one of the original four cantopop Heavenly Kings (四大天王), and possesses a rich baritone/tenor. He is sometimes called the God of Songs (歌神). His most famous work is perhaps Goodbye Kiss (吻别) – one of the best-selling albums of all time, with over 3 million copies sold in 1993 alone. Give the English or Romanized name of this singer.

Most Essential Python

Statement	::=	*function* (*CommaExprs*)
Statement	::=	if *Expr*:
		Statements
		else:
		Statements
Statement	::=	return *Expr*
Statement	::=	*variable* = *Expr*
Expr	::=	*Number* | *variable* | *String*
Expr	::=	*Expr BinOp Expr*
BinOp	::=	**+** | ***** | **==** | **<=** | ...

Trickier Python

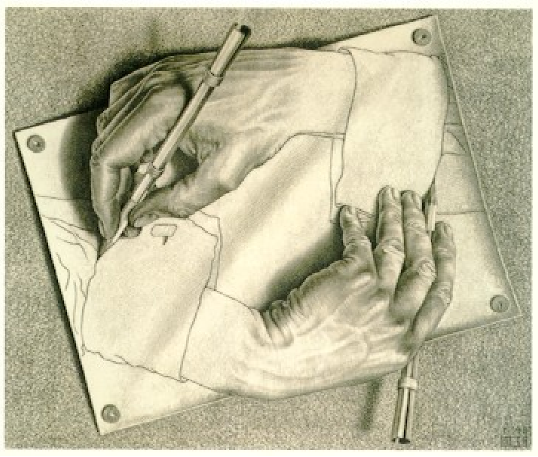
CommaExprs	::=	*Expr*
CommaExprs	::=	*Expr* , *CommaExprs*
Statements	::=	*Statement*
Statements	::=	*Statement*
		Statements
Expr	::=	[*CommaExprs*]
Statement	::=	def *function*(*CommaExprs*):
		Statements
Statement:	::=	for *variable* in *Expr*:
		Statements



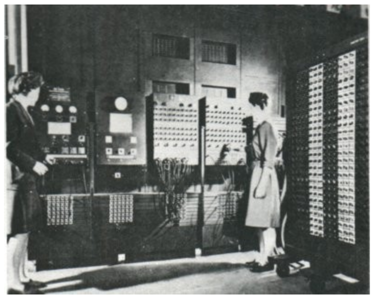
```
/usr/bin/python2.7 -u /home/weimer/src/pycharm-2.5.2/helpers/pydev/pydevconsole.py 529
PyDev console: starting.
import sys; print('Python %s on %s' % (sys.version, sys.platform))
Python 2.7 (r27:82500, Sep 16 2010, 18:02:00)
[GCC 4.5.1 20100907 (Red Hat 4.5.1-3)] on linux2
sys.path.extend([])
>>> print 2+2
4
>>> name = 'Wes Weimer'
>>> print name
Wes Weimer
>>> print name + ' and even more text'
Wes Weimer and even more text
>>> def cube(number):
...         return number * number * number
...
>>> print cube(3)
27
>>> animals = [ 'ant', 'bat', 'cat']
>>> for creature in animals:
...         print creature + " is an animal"
...
ant is an animal
bat is an animal
cat is an animal
>>> for x in [1,2,3,4]:
...         print cube(x)
...
1
8
27
64

>>>
```

Could not save project!: Unable to save project file... (8 minutes ago)

Rules of Evaluation & People



ENIAC: Electronic Numerical Integrator and Computer



- Early WWII computer
  - But **not** the world's first (PS4)
- Built to calculate bombing tables

Memory size:
twenty 10 decimal digit accumulators = 664 bits
ENIAC (1946): 3 mm
Apollo Guidance Computer (1969): 1 inch
You: 2.2 miles

Directions for Getting 6

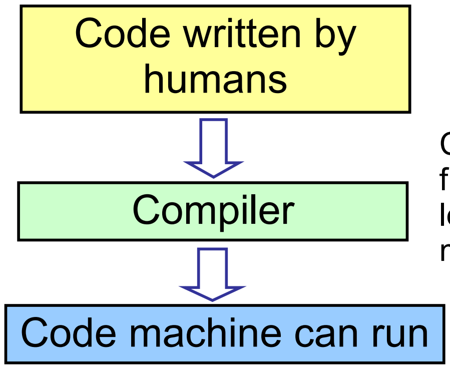
1. Choose any regular accumulator (ie. Accumulator #9).
2. Direct the Initiating Pulse to terminal *5i*.
3. The initiating pulse is produced by the initiating unit's *Io* terminal each time the Eniac is started. This terminal is usually, by default, plugged into Program Line 1-1 (described later). Simply connect a program cable from Program Line 1-1 to terminal *5i* on this Accumulator.
4. Set the Repeat Switch for Program Control 5 to 6.
5. Set the Operation Switch for Program Control 5 to ADD.
6. Set the Clear-Correct switch to C.
7. Turn on and clear the Eniac.
8. Normally, when the Eniac is first started, a clearing process is begun. If the Eniac had been previously started, or if there are random neons illuminated in the accumulators, the ``Initial Clear'' button of the Initiating device can be pressed.
9. Press the ``Initiating Pulse Switch'' that is located on the Initiating device.
10. **Stand back.**

Admiral Grace Hopper
(1906-1992)

"Nobody believed that I had a running compiler and nobody would touch it. They told me computers could only do arithmetic."

- Mathematics PhD Yale, 1934
- Entered Navy, 1943
- First to program Mark I (first "large" computer, 51 feet long)
- Wrote first compiler (1952) – program for programming computers
- Co-designer of COBOL (most widely used programming language until a few years ago)

USS Hopper

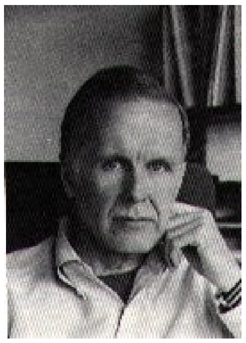


Compiler translates from code in a high-level language to machine code

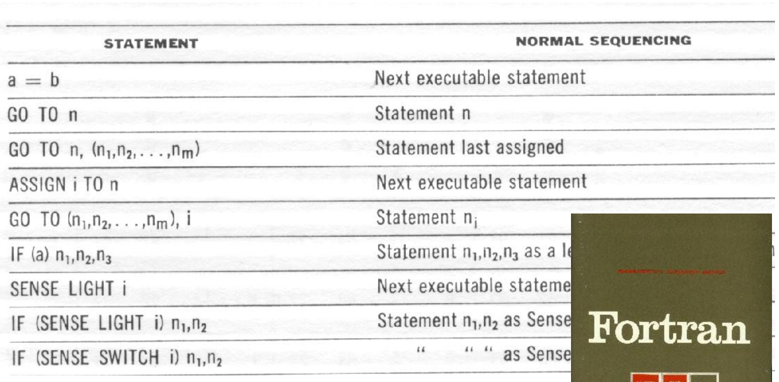
DrScheme uses an ***interpreter***. An interpreter is like a compiler, except it runs quickly and quietly on small bits of code at a time.

John Backus

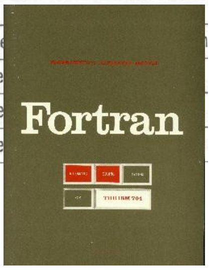
- Chemistry major at UVA (entered 1943)
- Flunked out after second semester
- Joined IBM as programmer in 1950
- Developed Fortran, first commercially successful programming language and compiler



IBM 704 Fortran manual, 1956



STATEMENT	NORMAL SEQUENCING
$a = b$	Next executable statement
GO TO n	Statement n
GO TO n, $(n_1, n_2, \ldots, n_m)$	Statement last assigned
ASSIGN i TO n	Next executable statement
GO TO $(n_1, n_2, \ldots, n_m)$, i	Statement n_i
IF (a) n_1, n_2, n_3	Statement n_1, n_2, n_3 as a l
SENSE LIGHT i	Next executable stateme
IF (SENSE LIGHT i) n_1, n_2	Statement n_1, n_2 as Sense
IF (SENSE SWITCH i) n_1, n_2	" " " as Sense



Describing Languages

- Fortran language was described using English
  - Imprecise
  - Verbose, lots to read
  - Ad hoc

```
DO 10 I=1.10
```
Assigns `1.10` to the variable `DO10I`
```
DO 10 I=1,10
```
Loops for `I = 1` to `10`

(Often incorrectly blamed for loss of Mariner-I)

- Wanted a more precise way of describing a language

Recall: Backus Naur Form

symbol ::= *replacement*

We can replace *symbol* with *replacement*

A ::= *B* means anywhere you have an *A*, you can replace it with a *B*.

nonterminal – symbol that appears on left side of rule

terminals – symbol that **never** appears on the left side of a rule

Language Elements

When learning a foreign language, which elements are hardest to learn?

- Primitives: lots of them, and hard to learn real *meaning*
- Means of Combination
  - Complex, but, all natural languages have similar ones [Chomsky]

SOV (45% of all languages)	*Sentence* ::= *Subject Object Verb*	(Korean)
SVO (42%)	*Sentence* ::= *Subject Verb Object*	
VSO (9%)	*Sentence* ::= *Verb Subject Object* “Lladdodd y ddraig y dyn.” (Killed the dragon the man.)	(Welsh)
OSV (<1%):	Tobati (New Guinea)	
Schemish:	*Expression* ::= (*Verb Object*)	

- Means of Abstraction: few of these, but tricky to learn differences across languages

  English: I, we

  Tok Pisin (Papua New Guinea): mi (I), mitupela (he/she and I), mitripela (both of them and I), mipela (all of them and I), yumitupela (you and I), yumitripela (both of you and I), yumipela (all of you and I)

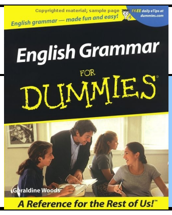
	Pages in *Revised[5] Report on the Algorithmic Language Scheme*	
Primitives		🟦
Means of Combination		🟦
Means of Abstraction		🟦
	48 pages total (includes formal specification and examples)	🟦

	Pages in *Revised^5 Report on the Algorithmic Language Scheme*	
Primitives	Standard Procedures	18
	Primitive expressions	2
	Identifiers, numerals	1
Means of Combination	Expressions	2
	Program structure	2
Means of Abstraction	Definitions	½
	48 pages total (includes formal specification and examples)	

#37

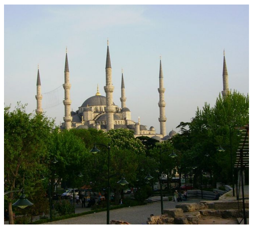
	Pages in *Revised5 Report on the Algorithmic Language Scheme*		Pages in C++ Language Specification (1998)	
Primitives	Standard Procedures	18		
	Primitive expressions	2		
	Identifiers, numerals	1		
Means of Combination	Expressions	2		
	Program structure	2		
Means of Abstraction	Definitions	½		
	48 pages total (includes formal specification and examples)			

	Pages in *Revised^5 Report on the Algorithmic Language Scheme*		Pages in C++ Language Specification (1998)	
Primitives	Standard Procedures	18		356
	Primitive expressions	2		30
	Identifiers, numerals	1		10
Means of Combination	Expressions	2	**C++ Core language issues list has 469 items!**	197
	Program structure	2		35
Means of Abstraction	Definitions	½	Declarations, Classes	173
	48 pages total (includes formal specification and examples)		**776** pages total (includes no formal specification or examples)	

	Pages in *Revised^5 Report on the Algorithmic Language Scheme*		English	
Primitives	Standard Procedures	18	Morphemes	?
	Primitive expressions	2	Words in Oxford English Dictionary	500,000
	Identifiers, numerals	1		
Means of Combination	Expressions	2	Grammar Rules	100s (?)
	Program structure	2	*English Grammar for Dummies* Book	384 pages
Means of Abstraction	Definitions	½	Pronouns	~20
	48 pages total (includes formal specification and examples)		 English Grammar FOR DUMMIES Geraldine Woods A Reference for the Rest of Us!	

Liberal Arts Trivia: Architecture

- Q. Name the distinctive architectural features of Islamic mosques that is typically a spire or onion-shaped dome, and is usually either free-standing or much taller than all surrounding structures. There are six in this picture of the Sultan Ahmed Mosque (Blue Mosque) in Istanbul:



#41

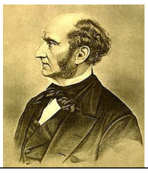
Liberal Arts Trivia: Egyptology

- Q. Name the last effective pharaoh of Egypt's Ptolemaic dynasty. She originally shared power with her father and her brothers, whom she also married, but eventually ruled alone. As pharaoh, she allied with Gaius Julius Caesar that solidified her grip on the throne. After Caesar's assassination in 44 BC, she aligned with Mark Antony in opposition to Caesar's legal heir Augustus. After losing the Battle of Actium to Octavian's forces, Antony committed suicide, and she followed suit, according to tradition killing herself by means of an asp bite on August 12, 30 BC.

#42

Liberal Arts Trivia: Philosophy

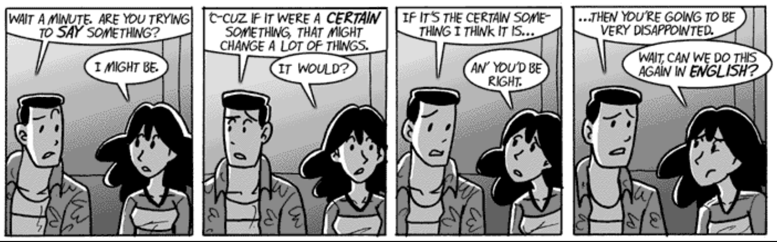
- Q. Name this 19th century philosophical work by John Stuart Mill. To the Victorian readers of the time it was radical, advocating moral and economic freedom of individuals from the state. Mill argues against the "tyranny of the majority" and articulates the harm principle: people can do anything they like as long as it does not harm others.



Evaluation Rules - Step by Step

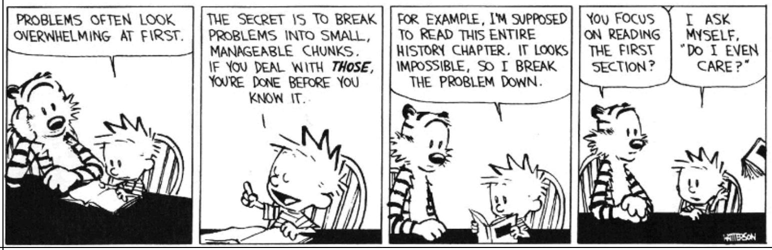
Expressions and Values

- (Almost) every ***expression*** has a ***value***
  - Have you seen any expressions that don't have values?
- When an expression with a value is ***evaluated***, its value is produced


WAIT A MINUTE. ARE YOU TRYING TO SAY SOMETHING?
I MIGHT BE.
'C-CUZ IF IT WERE A CERTAIN SOMETHING, THAT MIGHT CHANGE A LOT OF THINGS.
IT WOULD?
IF IT'S THE CERTAIN SOMETHING I THINK IT IS...
AN' YOU'D BE RIGHT.
...THEN YOU'RE GOING TO BE VERY DISAPPOINTED.
WAIT, CAN WE DO THIS AGAIN IN ENGLISH?

Five Types of Expression

1.**Primitives**	if <u>True</u>: <u>3</u>
2.**Names**	def square(n): return <u>n</u> * <u>n</u>
3.**Application**	<u>square(4)</u>
4.**Lambda**	<u>(lambda (q): 0 – q)</u> (7)
5.**If**	<u>if 3 <= 5: ...</u>


PROBLEMS OFTEN LOOK OVERWHELMING AT FIRST.
THE SECRET IS TO BREAK PROBLEMS INTO SMALL, MANAGEABLE CHUNKS. IF YOU DEAL WITH THOSE, YOU'RE DONE BEFORE YOU KNOW IT.
FOR EXAMPLE, I'M SUPPOSED TO READ THIS ENTIRE HISTORY CHAPTER. IT LOOKS IMPOSSIBLE, SO I BREAK THE PROBLEM DOWN.
YOU FOCUS ON READING THE FIRST SECTION?
I ASK MYSELF, "DO I EVEN CARE?"

Primitive Expressions

Expression ::= *PrimitiveExpression*

PrimitiveExpression ::= ***Number***

PrimitiveExpression ::= ***'String'***

PrimitiveExpression ::= **True** | **False**

PrimitiveExpression ::= ***Primitive Procedure***

Evaluation Rule 1: Primitives

If the expression is a ***primitive***, it evaluates to its pre-defined value.

```
>>> 3
3
>>> True
True
>>> +
Error!
```

Name Expressions

Expression ::= *NameExpression*

NameExpression ::= ***Name***

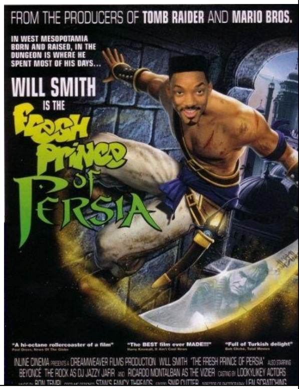
00 NAME LASTNAME RB
6'0" 000 LBS 00 SEASONS
This is the main text box where you can put up to 3 lines of information for your lower-third bio graphic

#49

Evaluation Rule 2: Names

If the expression is a ***name***, it evaluates to the value associated with that name.

```
>>> two = 2
>>> two
2
```


FROM THE PRODUCERS OF TOMB RAIDER AND MARIO BROS.
WILL SMITH IS THE FRESH PRINCE OF PERSIA

Application Expressions

Expression ::= *Application Expression*

ApplicationExpression

::= *Expression*(*CommaExprs*)

CommaExprs ::= *Expression*

CommaExprs ::= *Expression* , *CommaExprs*

#51

Evaluation Rule 3: Application

3. If the expression is an application:
   a) **Evaluate** all the subexpressions (in any order)
   b) **Apply** the value of the first (function) subexpression to the values of all the other (argument) subexpressions.

$\text{Expression}_0(\text{Expression}_1 , \text{Expression}_2 \ldots)$

#52

Rules for Application

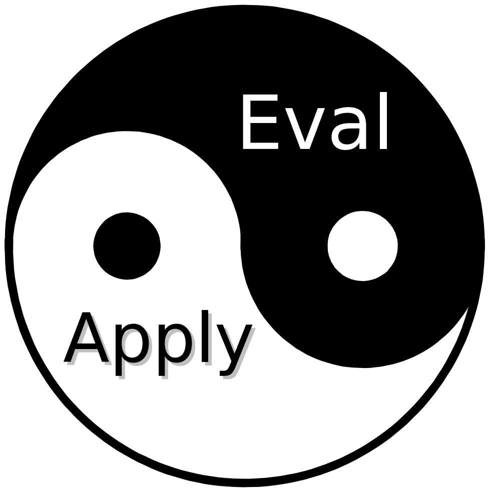
I. **Primitives.** If the procedure to apply is a *primitive*, just do it.

II. **Constructed Procedures.** If the procedure is a *constructed procedure*, **evaluate** the body of the procedure with each formal parameter replaced by the corresponding actual argument expression value.

#53

Eval and Apply are **defined in terms of each other**.

Without Eval, there would be no Apply, Without Apply there would be no Eval!



#54

Making Procedures

lambda means "make a procedure"

(you can also use **def** to make one!)

Expression ::= *ProcedureExpression*

ProcedureExpression ::=

(lambda (*CommaNames***) :** *Expression***)**

CommaNames ::= ***Name***

CommaNames ::= ***Name*** **,** *CommaNames*

ProcedureExpression ::=

(lambda : *Expression***)**

#55

Evaluation Rule 4: Lambda

4. Lambda expressions evaluate to a procedure that takes the given parameters and has the expression as its body.

Lambda is the English name for the Greek letter written λ .

#56

Lambda Example: Tautology Function

(lambda	*make a procedure*
:	*with no parameters*
True)	*with body* True

```
>>> (lambda : True)(1120)
TypeError: <lambda>() takes no arguments (1 given)
>>> (lambda : True)()
True
>>> (lambda (x) : x*3)(1120)
3360
```

#57

Evaluation Rule 5: If

if *Expression*$_{\text{Predicate}}$**:**

Expression$_{\text{Consequent}}$

else:

Expression$_{\text{Alternate}}$

To evaluate an if expression:

(a) Evaluate *Expression*$_{\text{Predicate}}$.

(b) **If** it evaluates to **False**, **0**, **""** or **[]** then the value of the if expression is the value of *Expression*$_{\text{Alternate}}$. **Otherwise**, the value of the if expression is the value of *Expression*$_{\text{Consequent}}$.

#58

Now You Know All of Scheme!

- Once you understand Eval and Apply, you can understand all Python programs!
- Except:
  - There are a few more special forms (like **if**)
  - We have not define the evaluation rules precisely enough to unambiguously understand all programs (e.g., what does "value associated with a name" mean?)

#59

Example: Nanostick

- How far does light travel in 1 nanosecond?

```
>>> nanosecond = (1.0 / (1000 * 1000 * 1000)) # 1 billionth of a s
>>> lightspeed = 299792458                    #m / s
>>> (lightspeed * nanosecond)
0.299792458  # just under 1 foot
```

Some Dell machines in Thornton have "1.8-GHz Pentium 4 CPU"s.

GHz = GigaHertz = 1 Billion times per second
They must finish a step before light travels 6.6 inches!

#60

Homework

- Read Structured Lab Guide (Today)
- Complete the Honor Pledge (due Wednesday in class, signed)
- Start PS 1 (due Thu Sep 06)

What I do when a teacher says "this cannot be done the night before"
🟦 Adhere the warning and start early
🟥 Take it as a personal challenge